SITUATIONAL FEATURES INFLUENCING MENTALISTIC EXPLANATIONS OF ACTION

By

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OF ACTION

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Actions are often assumed by humans to be compelled and directed by mental desires and beliefs. Although young children often attribute desires and beliefs to actors, little is known about how they calibrate those attributions, knowing when an occurrence should be explained on the basis of an actor's mental state and when an occurrence has other causal mechanisms (e.g., biological or physical). Accordingly, the goal of this research was to assess how children know <u>when</u> an action is mentalistically caused. Specifically, the research assessed whether variable self-initiated movement and perceptual access to goals act as cues guiding children's distinctions between actions in the world that should and should not be construed as mentalistically caused.

In Study 1, preschoolers, first graders, and adults chose whether an occurrence was caused by mental or physiological states of the actor. The occurrences differed in whether they were accompanied by the situational features listed above and in whether the actor was an artifact, insect, mammal, or human. At all ages mental explanations were preferred in the presence (but not the absence) of the three situational cues ($ps < .001$). Also, when the three cues were present, first graders and adults differentiated between artifacts and living organisms, providing mental explanations significantly more often when the actor was alive ($ps < .001$). Only adults, however, differentiated between "higher" and "lower" organisms, using mental explanations significantly more often ($ps < .001$) for mammals and humans than for insects.

In Study 2, preschoolers and first graders witnessed scenarios in which perceptual access or variable self-initiated movement was either present or absent. They were then asked to verbalize why the action occurred. In both age groups, mental explanations that appealed to the volition of the actor were more common when the feature of interest was present than when it was absent, $ps < .001$. Taken together, these studies suggest that young children are capable of abstracting features of action when construing its cause. Doing so apparently plays a

vital role in learning how (and when) to generalize mentalistic explanations to new situations.

INTRODUCTION

Throughout each day the perceptual world of humans is filled with the occurrence of physical actions taking place in varying forms and substance. A central task for adults and children is to understand and interpret the nature of these various actions by inferring their causes. One way to set about solving this task is by postulating that an actor's beliefs and desires are causally connected to that individual's actions. When mental states such as these are viewed as causal constructs, they are generally embedded within the various postulates and principles comprising a "theory of mind" (or "folk psychology") (see Gopnik, 1993; Wellman, 1990, for recent discussions about the nature of theories of mind).

In general, the central principles of a theory of mind state that unobservable mental states are causally connected to (a) sensory perception, (b) other mental states, and (c) behavioral output. For example, seeing a toy placed in a red drawer causes Billy's belief about its location. If one is aware that Billy desires to play with the toy, then it can be inferred that his belief about the toy's location will direct the action, motivated by his desire, of approaching and opening the

red drawer. In this example, Billy's perception of the toy, his belief and desire about the toy, and his action toward the toy are all interconnected, forming a framework within which one can predict and explain his action. Construing action within this framework is, in essence, folk psychology.

Literature Review

Although much research has demonstrated that young children can explain actions by appealing to actors' mental beliefs and desires (see Astington & Gopnik, 1991; Flavell, Miller, & Miller, 1993, for recent reviews), little is known about how children calibrate those attributions, knowing when an occurrence should be explained or expected on the basis of the mental states of an actor and when an occurrence has other causal mechanisms such as internal biological mechanisms or external physical forces. Accordingly, the aim of the following research is to explore potential situational cues which potentially guide children in parsing occurrences and phenomena into those which are and are not explicable via particular mental desires and beliefs. The question being explored is whether young children employ mental explanations of action indiscriminately or in a manner that is principled and constrained according to the presence of specific situational features.

What systems of explanation might compete with folk psychology in children's determinations of an action's

cause? Following Dennett (1987), two systems of explanation which are alternatives to folk psychology are the Design Stance and the Physical Stance. Explanations from the Design Stance are based upon the assumption that certain outcomes and actions occur because the actor, whether an artifact or natural kind, is specifically designed to do the particular action being explained. That is, design explanations are based upon the assumption that the actor is designed, or hardwired, with parts (biological or mechanical) that have a task to perform. For instance, one might explain a moth's evasive behavior in the presence of a bat, a chief predator, in terms of the moth's functional design ("moths are made to survive and that is why this moth is avoiding the bat" or "something inside moths compels them to survive and flee from bats"). The ringing of an alarm clock would be explained as occurring because the clock is designed to perform that very function. As considered in this paper, a Design Stance is not so much a teleological argument for an activity, but instead a rudimentary assumption that features intrinsic to an organism or machine are causally responsible for an observed activity or occurrence.

There is evidence that young children will appeal in a general way to the nature of an actor's design as an explanation of action and occurrences. When asked to explain the action of natural kinds (e.g., "why do

rabbits hop?"), preschoolers (72%) and young grade school children (73%) spontaneously offered a cause intrinsic to the actor (Gelman & Kremer, 1991). Examples of such explanations include "rabbits are made to hop" and "the leaf just makes itself change colors" (Gelman & Kremer, 1991, p. 411). When asked directly, children generally indicated that something "inside" of both artifacts and natural kinds caused events such as a bird flying or a car going up a hill (Gelman & Kremer, 1991). In addition, Springer and Keil (1991) have found that preschoolers believe that external characteristics of organisms are caused by internal, natural forces (e.g., a flower is red due to inheritance) rather than external causes such as a human painting the flower.

Similarly, Gelman and Wellman (1991) found that preschoolers' explanations of the behavioral functions of objects and organisms were more influenced by the internal constitution of the actor than by its external characteristics. For example, if one removed the insides of a dog, preschoolers realized that the dog could no longer physically function (e.g., bark or eat food). Further, they understood that removing external features of the dog, such as its fur, did not have a similar effect. These examples illustrate young children's assumption that functional design parts of organisms and artifacts can cause actions and outcomes.

R. Gelman (1990) suggests that preschoolers have an "innards principle" which assumes that natural objects have something inside them which governs their movement and change. Interviews with preschoolers (Gelman, 1990) reveal that they have realistic ideas and beliefs about the internal constitution of animate and inanimate objects. Animates were often said to have blood and bones inside them whereas the insides of inanimates were said to consist of human-made materials like cotton and plastic. Thus, even by preschool age, children appear to have expressible beliefs about the mechanical and biological design features characteristic of a variety of actors.

In addition to a Design Stance, one may adopt a Physical Stance, explaining actions, for example, by appealing in a rudimentary way to physical impingements responsible for movement. To illustrate, a common assumption is that movement can be caused when one object physically contacts another with a sufficient speed and force to propel it (Michotte, 1963). In the absence of such contact, movement is regarded as self-initiated. The contrast between these differences in the initiation of movement is salient even to infants, who dishabituate in response to such changes in movement (Leslie, 1984). More generally, children are often capable of distinguishing intentional from overt physical causes of behavior (see Wellman & Gelman, 1992, for a review of

this literature). To illustrate, Bullock and Gelman (1979) found that 4-year-olds explain the popping of a jack-in-the-box as resulting from the impact of a ball rather than the intentions of the jack-in-the-box.

Given the various systems of explanation possible for any action, how does one decide which explanation is most appropriate for any given action? Is there a clear preference across situations for one type of explanation over another, do preferences vary across situations, or do children simply regard all types of explanations as equally preferable, adequate, and acceptable in every instance? As noted earlier, the following research is designed to begin exploring these various possibilities by attempting to assess whether children are sensitive to the presence or absence of specific situational features which influence the manner in which an action's cause is construed.

Scenarios were developed in which situational features believed to implicate various mental explanations were either present or absent. If these features influence the manner in which an action is interpreted, then their presence should predictably result in mental explanations, whereas their absence might suggest the plausibility of searching for an alternative explanation. Studies 1 and 2 postulate three such features and explore their effects on children's explanations of action.

What situational features might imply that an action can be explained mentalistically? One feature is the self-initiation of action (Premack, 1990). Self-initiated action, considered in its broadest sense, is action that begins without any external forces acting on it (Mandler, in press). It has long been pointed out that adults commonly infer that self-initiated movement is psychologically or voluntarily caused (Heider & Simmel, 1944; Michotte, 1963, ch. 13). Generally, if an action is not self-initiated, then the only alternative explanation must involve appealing to the external force(s) impinging upon the actor (e.g., a Physical Stance) rather than an internal mental state or design feature.

Secondly, in a related fashion, the action must be variable; in other words, if an action is clearly intentional, then for every stimulus more than one response should be possible. If an action is instinctual or a reflex, then it can easily be explained by appealing to the physical stimulus eliciting the action or the biological instinct compelling the action (see Dretske, 1988, ch.2). For example, if moths are known to be instinctually drawn to flames, one could easily explain the moth's flight toward flames by appealing to its biological design ("it has to," "that's its nature," "all moths are drawn to light").

A third feature which may implicate mental explanations is the presence of <u>perception</u> toward a critical fact or event underlying an action. In folk psychology, beliefs and desires typically originate via perceptions; therefore, it is implausible for a particular belief or desire to be invoked as an explanation of an action if there has never been a perceptual experience by which that belief and/or desire could have been formed. For example, if Mary is walking in the direction of an ice cream store, one cannot explain Mary's action in terms of her belief about the location of the store or her desire for ice cream if she has never seen nor heard about the store and therefore does not know it exists. Of course, some beliefs are mentally constructed but, as a general rule, even the preceding beliefs from which the new belief is derived were formed at some point by a perceptual stimulus. Thus, to ascertain the <u>specific</u> beliefs and desires responsible for an action one must note the actor's perceptions responsible for forming the relevant beliefs and desires. The types of desires that can be used to explain a given action are limited by the knowledge one brings to a situation.

To address the extent to which these three features may influence the way action is construed, Study 1 explores their influence across a wide range of actors, varying from artifacts to humans. It is possible, for

example, that there may be a positive relation between the neurological sophistication of the actor and a willingness among subjects to impute mental states as explanations of that actor's behavior. In this case, subjects may use the biological differences among species of actors to infer how the action is caused instead of using the situational features surrounding the action. How far-reaching the features actually are can be illustrated by exploring whether or not they override in importance the biological nature of the actor.

The relation between the biological nature of the actor and inferring an action's cause can be framed by reviewing two ways in which the essence of folk psychological terms is defined by some philosophers of mind. Dennett (1987) suggests that beliefs and desires can be imputed to any system, ranging from thermostats to humans, so long as the actions of those systems can be reliably predicted and explained by appealing to mental constructs. The Instrumentalist position (Dennett, 1987) states that since the action of any number of biological or artifactual systems can be accurately predicted and explained by the constructs of beliefs and desires, the utility, and hence importance, of these constructs is independent of whatever ontological assumptions one might hold about them. The real properties of mental states, whatever they may be, are secondary considerations when compared to their utility in explaining action. In

contrast, others (e.g., Fodor, 1987) emphasize that beliefs are significantly more than instrumental constructs: Mental states are said to have real physical properties found only in highly sophisticated representational systems such as the human brain. In other words, a defining attribute of a mental state is its real physical properties. Thus, physical considerations might be regarded as preconditions for deciding whether an action has a mentalistic explanation.

These two philosophical positions can be taken to suggest different ways in which subjects might invoke mental explanations of action when the situational features are present. On the one hand, they might impute mental states to explain action regardless of the biological features of the actor, so long as certain contextual preconditions are met (i.e., the three situational features above). They may do so even if they believe that only complex organisms truly have a mind. However, it is also possible that one's assumption about the literal physical properties of beliefs and desires may affect one's decision to use mental states as explanations of action. In other words, there might be a direct relation between judgments of whether a particular organism is sophisticated enough to be sentient and a willingness to use a mental state as a causal explanation for the action of that organism.

If subjects in Study 1 are Realists, then even preschoolers, who have correctly denied mental states to artifacts in past research (e.g., Berzonsky, Miller, Woody-Ramsey, & Harris, 1988; Gelman, Spelke, & Meck, 1983), should mentalistically explain the actions of artifacts infrequently (especially when a plausible alternative explanation is provided for them). In contrast, most children (as well as adults) accept that "higher" mammals and humans have sentient experiences (e.g., Carey, 1985; Inagaki & Sugiyama, 1988), meaning that, if they are Realists, one should expect a fairly high degree of mental explanations for the actions of nonhuman mammals. The number of mental explanations for insects should be intermediate if subjects are Realists since the percentage of children and adults who indicate that insects can have thoughts and feelings rarely approaches 100% and varies greatly with differences in wording and target (e.g., Carey, 1985; Inagaki & Sugiyama, 1988).

Present Study

The purpose of Study 1 is to examine whether the presence of the three situational features detailed above is a sufficient condition for compelling mentalistic explanations of action. Equally important is the question of whether the four categories of actors used in this study (human, mammal, insect, artifact) interact with the presence of the three features in subjects'

determinations of whether the action is to be explained mentalistically. The presence of such an interaction will be tested by determining whether there is a significant difference in the number of children's mentalistic explanations among the four categories of actors.

Subjects were provided with both design and mental explanations following each action. Design explanations appeal to functional, physical properties that are intrinsic to the actor. If subjects consistently use them primarily for specific categories of actors, then it can be inferred that the effect of the three principles in producing mentalistic explanations is mediated by the category of the actor. Explanations from a Design rather than Physical Stance are chosen as alternatives to mental explanations because the movement in each scenario is self-initiated, meaning that only internal or intrinsic features of the actor are plausible explanations.

EXPERIMENT 1

Method

Subjects

Three age groups, each consisting of 24 subjects, were tested. There were 13 male and 11 female preschoolers (range 4-8 to 5-8; mean = 5-2), 14 female and 10 male first graders (range = 6-4 to 7-8; mean = 7-0), and 12 male and 12 female adults (introductory psychology students). Children were drawn from predominantly middle-class populations.

Materials

For each of 16 scenarios, an illustration depicting the action to be explained was drawn on 20 x 28 cm paper. Every actor was depicted realistically, with no suggestion of anthropomorphic features on the nonhuman actors. Across drawings each actor was sized roughly proportional to one another. Actors did not directly face the viewer, preventing the presence of emotional cues which might be derived from facial expressions (Lillard & Flavell, 1990).

Procedure

Actions in each of the 16 scenarios were self-initiated, accompanied by sensory perceptual access to facts surrounding the action, and were one of two

occurrences that potentially could have taken place (see Table 1). Upon describing each action to the subject, the experimenter concluded by asking, "Why is (the actor) doing that?" Design and mental explanations of the action were then provided and subjects were asked to make a forced choice between the two.

Across all stories, each of the three situational features was presented as similarly as possible. To indicate an action's variability, each story contained the phrase, "(The actor) can either (action A) or (action B)." For the "sensory perception" feature, every story mentioned a specific sensory ability in the present tense: "(The actor) sees/feels/hears etc. (an object)." In each story perception formed a belief about the nature, location, and/or existence of the object toward which the action was directed. The "self-initiating" feature was established by explicitly stating the verb describing the action (e.g., "The actor is walking/eating/flying/running" etc.). In no case was a potential external causal agent mentioned, implied, or depicted.

Altogether there were four scenarios for each of the four actor categories. Of the four scenarios within each actor category, two were "neutral" stories and two were "anomalous" stories (Bartsch & Wellman, 1989). Neutral stories merely presented the occurrence of an action. For example, in one scenario a cat ran inside a house.

Table 1

Description of Scenarios Used in Experiment 1

Actor	Perception	Variability	Action
Billy	sees bed	search outside/ search under bed	searching for toy under bed
Judy	sees clouds	carry umbrella/ leave it behind	removes umbrella from closet
Harvey	sees snake	pick it up/ run away	runs away
Susie	sees lollipops	purchase lollipop/ purchase candy bar	purchasing a lollipo
Horse	sees apples	run toward barn/ run toward apples	running toward apples
Squirrel	sees a nut	stay in tree/ retrieve nut	retreiving nut to tree
Cat	sees open door	fall asleep/ go through door	running through doorway
Dog	sees car keys	stay home/ follow driver to car	following driver to car
Grass hopper	hears loud noise	remain stationary/ climb tree	climbing a tree
Spider	sees juice	walk to web/ drink juice	walks to juice
Ant	smells sugar	walk home/ walk to sugar	walks to sugar
Bee	sees colors	fly to colors/ fly home	flying to colors
Orange Machine	sees orange rocks	put rocks in bag/ leave rocks on ground	placing rocks in bag
Train	wheels feel tracks	go short way/ go long, safe way	going long, safe way
Computer	hears inquiry	print answer A/ print answer B	printing answer A
Car	feels water	keep top down/ put top up	putting car top up

No details were provided to suggest that the action was somehow inconsistent with whatever desires the cat may have had. In neutral stories the action could sufficiently be explained as motivated by the actor's desire (e.g., "the cat wants to go into the house"). In contrast, anomalous stories described an action that, placed in the context of the actor's apparent desires, would actually contradict those desires. For example, in one scenario the protagonist was looking for his airplane under a couch although it was really outside. In another story, a bee flew toward colorful rocks that, from a distance, had the misleading appearance of flowers. In anomalous stories a desire-based explanation is insufficient because the action does not bring about the outcome apparently desired by the actor. However, reference to the actor's belief (e.g., "he thinks the plane is under the couch") explains the seemingly erroneous direction of the action. The two different types of stories were presented to increase the generality of the study by providing settings in which both desires (neutral stories) and beliefs (anomalous stories) are appropriate and commonly used explanations.

Accordingly, "wants to" was the mentalistic explanation provided for subjects in the neutral situation and "thinks that" was the mental alternative for the anomalous stories. The design explanations paired with the mental explanations were "made so that it

will do X" and "something inside makes it do X." Preschoolers have used and understood these terms in past research (Gelman & Kremer, 1991; Gottfried & Gelman, 1992). The four explanations were consistently worded in the following fashion: "Because the actor is made so that (it will do the behavior)," "Because something inside the actor makes it (behavior)," "Because the actor wants to (behavior)," and "Because the actor thinks (fact explaining behavior)." For example, in a scenario in which subjects were told about a horse moving toward an apple that looked real but was actually plastic, they were asked, "The horse is running toward the plastic apple. Why is the horse doing that? Because the horse is made so that it will go to things that look like apples or because the horse thinks the plastic apples are real?" In another scenario, in which a convertible car automatically put its top up after water reached the seats, children were asked, "Why is the car doing that? Because the car thinks it is raining or because something inside the car makes it put the top up when it gets wet?"

Overall, the two mental explanations were paired equally often with the two different design explanations. The four resulting pairs were equally distributed within each of the four categories of actors. Thus, in the anomalous stories (there were two per each actor category), "thinks" was paired once with each of the two design responses within every actor category. Similarly,

in the neutral stories "wants" was paired with the two design explanations for each actor category. For each age group, the 16 scenarios were presented in four random orders, with the only constraint being that no more than two scenarios with the same actor category were presented in a row. The order of presentation of the design and mental choices was successively alternated across scenarios. For half of the subjects, the design explanation was presented first in the initial scenario while the reverse was true for the remaining subjects.

Following the 16 scenarios, five control events were presented (see Table 2). The control events were natural or mechanical events occurring without the presence of the three critical situational features. The events were not illustrated and were constructed primarily to examine whether children would reject a mental explanation and choose a plausible alternative (design explanation) when none of the three situational features were present. This is a necessary control because choosing the mentalistic explanation when the three features are present is interpretable only if the alternative choice is also shown to be a meaningful and comprehensible term.

The five events were administered in an invariant order. For each of the control events one of the two

Table 2

Control Events Used in Experiment 1

1. Why does a light bulb shine?
2. Why does a toaster get hot?
3. Why does a telephone ring?
4. Why does a puppy grow?
5. Why does a baby grow?

design explanations was paired with "wants." Each design explanation was used at least once for each of the two types of events (animate and artifact). The order in which design and mental explanations were presented was alternated across trials. The control events always followed the 16 scenarios since pilot testing revealed that even the youngest children had a clear preference to use design explanations for these occurrences. It was feared that placing the events early in the procedure might bias children's subsequent responses toward design explanations.

Finally, the relation between subjects' beliefs about the ability of artifacts to have sentient experiences and a willingness to mentalistically explain artifacts' actions was assessed. Three short questions concluded the testing session, probing children's beliefs about whether artifacts ("machines like cars and trains") (a) have brains, (b) can think, and (c) can feel happy and sad. To ensure that children did not respond to the items with a "yes" or "no" bias, two filler questions were also asked, designed to evoke a "no" and "yes" response respectively.

Each testing session began by telling subjects, "I'm going to show you some pictures and tell you some stories. In each story something happens." Subjects were informed that they would hear two answers explaining why the action occurred and were to choose the better of

the two. Adult subjects then proceeded to read the scenarios themselves, examine the accompanying picture depicting the action, and then mark their responses on individual answer sheets. For children, two warm-up trials were administered to familiarize them with choosing between two causal explanations. First, they were shown a musical top and told, "Here is a toy. When it spins, music plays." As the musical top was spinning, children were asked, "Why is music playing? I'm going to give you two answers and you tell me which one is right. Is music playing because the toy is red or because the toy has something inside that makes it play music?" To avoid biasing children's subsequent responses in the test trials, the experimenter did not indicate whether the subject's response was correct or incorrect. Moreover, the design and mental explanations were not pitted together so that a response bias toward one explanation over the other could not be established in the warm-up trials.

For the second warm-up trial, children were told to "pretend you see some ice cream in the refrigerator and you take it out and eat some. Now why would you do that, because you wanted to eat ice cream or because the refrigerator is white?" Again, the experimenter did not reinforce or correct the child's answer to this question. Following the second warm-up trial, children were told, "Sometimes 'wants' and 'thinks' might be the better

answer and sometimes 'made that way' and 'something inside' might be the better answer."

The warm-up trials were presented in the same order as above for all children since pilot testing revealed that young children found the spinning top particularly engaging and thus an effective way to begin the testing procedure. Every first grader answered both warm-up trials correctly. For preschoolers, 83% were correct with regard to the spinning top, but only 50% correctly chose that one would retrieve ice cream from the refrigerator because one wanted to eat it.

Scoring

Scores were assigned to subjects by calculating the percentage of mental explanations and design explanations for each of the four categories of actors, as well as for the five control events.

Results

There were no main effects for gender or order, nor did they interact with any of the variables of interest (age and actor), so they will not be considered further.

Table 3 illustrates the percentage of mental explanations of action when the three features were present for each category of actor. Compared against a 50% baseline (chance-level), the percentage of children's mentalistic explanations across all four actor categories is significantly greater than chance. The percentage of preschoolers' mental explanations when the situational

Table 3

Mean Percentage of Mental Explanations Across Actors in Experiment 1

	Age		
	Pre-K	1st	Adult
Type of Actor			
Artifact	.71**	.65*	.11**
Insect	.74**	.91**	.49
Mammal	.88**	.98**	.82**
Human	.85**	.96**	.85**

* Means are significantly different from chance (50%) at $p < .01$, two-tailed significance level

** Means are significantly different from chance (50%) at $p < .001$, two-tailed significance level

features were present ranged from 71%, $t(23) = 4.46$, $p < .001$, for artifacts to 88%, $t(23) = 9.42$, $p < .001$, for mammals. Similarly, mental explanations for first graders ranged from 65%, $t(23) = 2.60$, $p < .025$, for artifacts to 98%, $t(23) = 33.05$, $p < .001$, for mammals. Clearly, children preferred to explain action surrounded by the three situational features with mental rather than design explanations and, in general, this preference held regardless of the biological category of the actor.

In contrast to children, adults' mental explanations of action were reserved primarily for mammals (82%) and humans (85%). Mental explanations in these two categories were significantly greater than chance level (50%), $t(23) = 7.84$, and $t(23) = 7.89$ respectively, ps < .001. Unlike children, mental explanations for insects (49%) were at chance-level, $t(23) = .16$, n.s. Adults also differed from children by using design explanations significantly more often than chance (89%) to explain the actions of artifacts, $t(23) = 9.08$, $p < .001$.

A 3 (age) x 4 (actor) mixed analysis of variance revealed a main effect for actor, $F(3,71) = 70.67$, $p < .001$, as well as for age, $F(2,69) = 33.35$, $p < .001$. There was also an age x actor interaction, $F(6,207) = 13.06$, $p < .001$.

Overall, preschoolers ($M = .79$), $t(23) = 5.83$, and first graders ($M = .87$), $t(23) = 7.87$, were much more likely to use mental explanations than were adults ($M =$

.57), *ps* < .001. The difference in the number of mental explanations between children and adults is primarily the result of children using mental explanations for artifact and insect actions significantly more often than adults (Table 4). The difference between first graders and preschoolers was marginally significant, $t(23) = 2.03$, $p = .046$.

Regarding the main effect of actor, mental explanations (collapsed across age) were used equally often for mammals ($M = .89$) and humans ($M = .89$). These percentages of mental explanations are significantly higher than the percentages for insects ($M = .71$) and artifacts ($M = .49$), *ps* < .001. The difference between insects and artifacts is also significant, $p < .001$.

Differences in the number of mental explanations between different actors were also assessed within each age group. Post-hoc comparisons between actors were conducted using Bonferroni-corrected t-tests (dividing the .05 alpha level by the number of comparisons within each age group, 6). Adults discriminated among all of the actors in their explanations except between mammal and human actors (see Table 5). First graders did not significantly differentiate in their use of mental explanations among living organisms, but they did differentiate between artifacts and the remaining three animate actors (see Table 5). In contrast, although the percentage of mental explanations by preschoolers

Table 4

Age Comparisons Within Actor in Experiment 1

Actor			
Artifact	Insect	Mammal	Human
A < P**	A < P*	A & P n.s	A & P n.s
A < 1**	A < 1**	A < 1**	A & P n.s
P & 1 n.s	P < 1*	P & 1 n.s	P & 1 n.s

Note. The differences in mental explanations between actors were calculated using Bonferroni-corrected *t*-tests. A = Adults, 1 = First graders, and P = Preschoolers.

* $p \leq .01$, two-tailed significance level
** $p \leq .001$, two-tailed siginficance level
n.s. $p > .016$

Table 5

Actor Comparisons Within Age in Experiment 1

Comparison	Pre-K	1st	Adult
	Age		
Between Actors			
Artifact < Insect	n.s	*	*
Artifact < Mammal	n.s	*	*
Artifact < Human	n.s	*	*
Insect < Mammal	n.s	n.s	*
Insect < Human	n.s	n.s	*
Mammal < Human	n.s	n.s	n.s

Note. The differences in mental explanations between actors were calculated using Bonferroni-corrected *t*-tests.

* $p < .001$, two-tailed significance level

increased from artifacts to mammals and humans, their differentiations among these different actors were not statistically significant.

Since children tended to explain artifacts' actions mentalistically when the three features were present, it is possible to explore whether there is a relation between such explanations and their judgments about whether artifacts can think, be happy and sad, and have brains. For the most part, subjects answered these questions sensibly, although three preschoolers and one first grader said "no" to every question (including the filler questions) and one preschooler answered "yes" to every question. The question of whether artifacts have brains proved to be easiest as every subject, with the exception of one preschooler, answered it correctly. Similarly, Johnson and Wellman (1982) found that a majority of 4- and 5-year-olds believed that dolls do not have brains. Taken together, such results indicate that preschoolers are clearly aware that a fundamental biological difference exists between artifacts and animate objects. However, as this study suggests, when children explain action they apparently do not regard the presence of a brain as a necessary prerequisite to imputing mental explanations.

None of the adults indicated that artifacts could have mental experiences. Similarly, only 6/24 (25%) of first graders indicated that artifacts could experience

emotions and 1/24 (04%) said that artifacts could think. Compared to first graders, a significantly higher percentage of preschoolers (58%) indicated that artifacts could think, $\underline{X}2$ (1, $\underline{N}$ = 48) = 16.38, $\underline{p}$ < .001. Of these children, all but one of them also believed that artifacts could be happy (54%), $\underline{X}2$ (1, $\underline{N}$ = 48) = 4.27, $\underline{p}$ < .05. Thus, there was consistency in preschoolers' judgments in that they either assumed that both mental states were present or that both were absent, $\underline{p}$ > .10 (McNemar's test). Overall, the correlation among preschoolers between affirming that artifacts can experience emotions and thoughts (range 0-2) and choosing mentalistic explanations of artifact behavior when the three cues were present (range 0-4) was not significant, $\underline{r}$ (24) = .23, $\underline{p}$ > .10 (this correlation is also not significant when removing the data of the four preschoolers who demonstrated a "yes" or "no" bias). This suggests that beliefs about whether artifacts can have sentient experiences were not driving preschoolers' decisions to mentalistically explain artifacts' action. This also appears to be true for first graders, who used mental explanations for artifacts a majority of the time even though they generally denied that artifacts can have sentient experiences.

Turning to the control events, the overall percentage of mental explanations when the three cues were present ($\underline{M}$ = .75) was significantly greater than

when they were absent (in the control events) ($\underline{M}$ = .11), $\underline{F}(1,69) = 665.11$, $\underline{p} < .001$. Mental explanations were much more frequent when the three cues were present than in the control events for preschoolers ($\underline{M}$ = .79 and $\underline{M}$ = .28 respectively), $\underline{t}(23) = 10.07$. $\underline{p} < .001$, first graders ($\underline{M}$ = .87 and $\underline{M}$ = .05), $\underline{t}(23) = 18.27$, $\underline{p} < .001$, and adults ($\underline{M}$ = .57 and $\underline{M}$ = .00), $\underline{t}(23) = 20.02$, $\underline{p} < .001$. For each age group, the percentage of design explanations for the control events was significantly greater than would be expected by chance (50%), $\underline{p}$s < .001.

Further analysis of performance on the control events revealed a main effect of age, $\underline{F}(2,69) = 30.43$, $\underline{p} < .001$ and an interaction between presence of the three features and age, $\underline{F}(2,69) = 14.38$, $\underline{p} < .001$. Preschoolers were more likely to use mental explanations for the control events than were first graders, $\underline{t}(23) = 3.90$, $\underline{p} < .01$, and adults, $\underline{t}(23) = 5.41$, $\underline{p} < .001$. The difference between adults and first graders was not significant, $\underline{p} > .10$. The interaction reflects that preschoolers' used mental explanations more often than first graders for the control events, while the opposite was true for the scenarios featuring the three cues. Altogether then, preschoolers tended to use mental explanations for the control events most often among the three age groups. However, each age group clearly used different explanations for the control events compared to the scenarios with the three situational features.

Within the control events, preschoolers were significantly more likely to attribute a mental explanation for the animate occurrences ("why does a puppy/baby grow?") ($\underline{M}$ = .42) than for the three artifactual occurrences ($\underline{M}$ = .17), $\underline{t}(23) = 2.62$, $\underline{p} < .025$. In contrast, first graders and adults were equally likely to give design explanations for both animate and inanimate events. Nevertheless, mental explanations among preschoolers were more likely in the presence of the three features than for animate occurrences in the control events, $\underline{t}(23) = 3.96$, $\underline{p} < .01$. In fact, artifact actions occurring when the three cues were present were more likely to be explained mentally by preschoolers than were animate occurrences in the control events, $\underline{t}(23) = 2.81$, $\underline{p} < .01$.

The preference among the age groups for design explanations in the control events is notable for two reasons. First, it indicates that, even for children, the design explanations were not inherently awkward or meaningless. Subjects showed a clear preference for them in situations where perceptual access, self-initiated movement, and behavioral variability were not factors related to the occurrences being explained. Secondly, it suggests that children's mental explanations are not indiscriminate, but are sensitive to the presence or absence of situational constraints. That is, one can infer that the three situational features implicate

mentalistic explanations since such explanations are common in their presence and substantially decrease in their absence. This issue is pursued more directly in Study 2.

One final issue, regarding the validity of the scenarios, is whether the four scenarios within each actor category were explained similarly to one another. Such similarities would suggest that variables among the stories which were peripheral to (a) the biological category of the actor and (b) the presence of the three features were not influencing how actions were explained. The four scenarios within each category were paired and a McNemar's test for significance was used to compare them. Alpha-level was adjusted by using a Bonferroni correction (dividing the .05 Alpha-level by the number of comparisons within each actor category for each age group, 6). For preschoolers, there were no significant differences in the percentage of mental or design explanations among the story pairs within each of the four categories. In other words, within each of the actor categories the four stories were generally explained in similar ways by children. For the first graders, only one pairing of items (in the Artifact category) was answered differently. Adults were somewhat more discriminating than children, treating three pairs of items differently, one each in the insect, mammal, and human categories. Because so few (4 of 72) comparisons

were statistically significant, no reliable patterns emerged to adequately explain why the four pairs were explained differently by subjects. In sum, subjects apparently were not overly influenced by extraneous variables in the scenarios. Instead, they were equally likely to explain pairs of scenarios within a category in the same fashion, using either the design terms or the mental terms for each item within a pair.

Discussion

Study 1 explored the extent of the influence of situational conditions hypothesized to implicate mental states as causes of action. Results suggested that when actions were self-initiated, variable, and accompanied by perceptual access informing beliefs and desires, children consistently chose mental explanations of the action over design explanations. They did so across a wide range of actions and actors. Adults were more selective than children when the situational features were present, reserving mental explanations primarily for humans and mammals. In the absence of the three situational features, the proportion of mental and design explanations was reversed for all age groups. A number of significant points follow from these results.

To begin, this is the first study to directly investigate the generality of children's theory of mind by equating on important dimensions the actions of a wide range of actors and examining the extent to which mental

explanations are used for such actions. Both preschoolers and first graders used mental explanations more often than would be expected by chance for all categories of actors, doing so significantly more often than adults for insects and artifacts. Thus, children's theory of mind generalizes across biological categories of actors. The generality of the theory of mind can be regarded as robust since children were given a choice between mental explanations and a plausible alternative explanation. The design explanations provided an important control for a possible linguistic bias toward using mental explanations since the content of children's earliest causal explanations are generally mentalistic (Hood & Bloom, 1979).

With development, the biological nature of the actor becomes an increasingly influential element in children's causal inferences, overriding in importance the presence of the three features. There is an emerging delineation among first graders between artifacts and living actors. Although they mentalistically explain the actions of artifacts more often than would be expected by chance (Table 3), and significantly more often than adults (Table 4), they also use mental explanations significantly less often for artifacts than for animate actors (Table 5). Thus, although first graders are primarily mentalistic (somewhat more so, in fact, than preschoolers), they are nevertheless beginning to refine

and limit such explanations, with the initial demarcation being drawn between living and nonliving actors. By adulthood, this distinction is nearly absolute and a further distinction between "lower" and "higher" animate organisms is also made. Clearly, adults inferred causes of action on the basis of category membership, inferring mental causes significantly less for insects and artifacts than for mammals and humans.

Children's failure to infer causes on the basis of the actor category is likely due to factors other than an inability to make the categorical distinctions being tested. Preschoolers and first graders can conceptually differentiate among artifacts, insects, mammals, and humans (see Keil, 1992; Wellman & Gelman, 1992 for recent discussions), selectively attributing characteristics to each and, further, believing that the internal constitution of a species can make it distinct and unique from other species (see Keil, 1989). Also, one might protest that children mentalistically explained artifacts' action because the presence of perceptual abilities suggested to them that the artifacts were alive. However, this argument misses the point in that the goal of the study was to assess what situational features would influence children to use mentalistic explanations. When perceptual abilities were a feature of the action of the artifact, mentalistic explanations

were used. When they were not (in the control events) design explanations were used.

More to the point, it is unlikely that children's mental explanations for artifacts' actions are the result of a pervasive animism. For example, in this study, even the youngest children used design explanations instead of mental explanations when explaining the activities of artifacts in the control events. Another potential explanation for children's preference for mentalistic explanations across actor categories is that the alternative design explanations were meaningless. However, the consistent use of design explanations for the control events demonstrates that mental explanations were not being chosen by default when the three features were present, but rather were being chosen over terms equally meaningful and comprehensible to children.

Instead, it may be that children base inferences about the causes of action more on the situational features surrounding the action than on the biological category of the actor. A similar finding illustrating the importance of situational features relative to category membership, when drawing causal inferences, comes from Gelman and Kremer (1991). They found that the type of occurrence being explained (e.g., a rabbit hopping or milk freezing) was as important as the biological category of the actor (animate or inanimate) in influencing such inferences. When asked whether an

occurrence had an internal cause, children were more likely to answer affirmatively for the actions of artifacts than for the actions of natural kinds. However, children also used a second dimension by which to infer causes of an occurrence: They were also more likely to attribute internal causes to occurrences that appeared to be self-generated than to outcomes which appeared to be externally caused, regardless of the biological category of the actor. Thus, internal causes were considered more likely for artifacts than for natural kinds and more likely for self-generated activity than for externally generated activity.

Along the same lines as Gelman and Kremer (1991), the present study suggests that, for children, the manner in which an action occurs may initially be an important basis from which to infer its cause, even more so, perhaps, than the biological category of the actor. Although many children in this study did not believe that artifacts could think or experience emotion (see also Carey, 1985), they were more flexible than adults in their willingness to use these mental states to explain the action of artifacts. The generality and power of the theory of mind for children seems to come from abstracting features of action, not from associating categories of actors with mental states and categorically imputing mental states as causes only to particular species of actors. In this respect, children have the

appearance of being Instrumentalists, using mental states as explanations of action independent of whether the actor is sentient. Perhaps they do so because their theory of mind has proven to generally be a successful way to make sense of their world and, therefore, as a matter of parsimony is extended to a variety of actors.

In contrast, adults make use of biological categories to infer the cause of action, perhaps being influenced by the neurological differences distinguishing each category. Thus, with development, category membership and features of action are integrated, meaning that the features surrounding an action and the biological nature of the actor are used to infer causes of action.

The findings from Study 1 are also significant in that they are the first attempt to systematically compare children's use of design explanations with mental explanations. If it is true, as Gelman (1990) argues, that children have an "innards principle" which governs their explanations of action, then it is important to specify the conceptual distinctions derived from such a principle. That is, (a) do children distinguish design features which are internal or intrinsic to the actor from internal mental states and (b) if so, how do they determine when each system of explanation is causally responsible for an action? The results of Study 1 indicate a clear distinction is made, even among

preschoolers, between the different types of explanations. That is, preschoolers, like adults, used the design explanations significantly more often when the three situational features were absent than when they were present. Thus, young children not only appeal to internal, nonobvious, causes of action (Wellman & Gelman, 1992), but they also discriminate between different types of nonobvious causes by consistently associating mental and design explanations with different types of phenomena. Future research should further address children's comparisons between design and mental explanations, more closely examining situational features which implicate to children that design states are responsible for the action being explained.

In sum, Study 1 illustrates that the three situational features are conducive to mental explanations of action. With development, biological considerations increasingly become important relative to the three features. The clear reversal in the percentage of mental and design explanations when the three features were absent suggests that the features are important preconditions for explaining an action mentalistically. Study 2 examines this issue directly. In that study, situations are equated on every dimension except for the presence or absence of a relevant situational feature. The question posed is whether causal explanations change depending on the presence or absence of each feature.

EXPERIMENT 2

Experiment 2 assessed whether varying the presence of the situational features affected the nature of children's spontaneous causal explanations of action. The features were systematically varied so that 1/4 of the actions children explained were externally caused (SI-), 1/4 were self-initiated (SI+), 1/4 occurred when perceptual access to a key event was lacking (PA-), and 1/4 occurred when perceptual access was present (PA+).

Since the presence of behavioral variability is generally linked with self-initiated movement, the two were considered as simultaneously present or absent in this study. Only in unusual circumstances, such as being commanded to move in a particular fashion, might action be self-initiated (physiologically, at least) without being considered variable or optional. Similarly, externally caused movement is not usually considered optional. An exception occurs when one is given a choice of how to be transported and chooses an external force as a causal agent. Nothing in the scenarios in Study 2 suggested exceptional instances in which self-initiated movement and behavioral variability did not co-occur. There was no implication that the self-initiated movement was the only action possible nor was there any indication that the external causal agent was

deliberately chosen by the actor. Thus, self-initiated movement and perceptual access were the primary variables of interest in this study.

If children's theory of mind is adult-like, then they should be sensitive to the removal of either self-initiated movement or perceptual access, adjusting their explanations accordingly. As discussed earlier, removing these situational features often makes mentalistic explanations of action implausible within an adult-like folk psychology. For example, when an action is not self-initiated, such as when someone is pushed into a swimming pool, the action is readily explained as being caused by the physical event initiating the movement (e.g., "he's going into the pool because someone pushed him"). In a similar fashion, it is implausible to indicate that an actor's desire for an outcome is causing an action if perceptual access necessary for awareness of the outcome is lacking. In such instances, a number of other types of explanations are possible, including appeals to either physical events, false beliefs, or ignorance. However, an action is generally not considered intentional if the actor is unaware that he is accomplishing the action.

An important control in the following study is that children's explanations of action cannot be based solely on the intrinsic desirability of the action. This is so because, even though each pair of actions differs in either the presence of perceptual access or the manner in which

they are initiated, the actions themselves are identical within each pair. In this way, any differences which emerge in how a pair of actions is explained can only be attributed to the differences in how each action was initiated or perceived by the actor. For example, in one pair of stories a bracelet is being thrown away. The manipulation is whether the actor saw the bracelet amidst the trash before throwing it away. Thus, the action of throwing away the bracelet is identical for each story in the pair and only the presence of perceptual access varies. By equating the actions on every dimension except the feature being manipulated, this study differs from a previous investigation of similar issues (Smith, 1978).

For example, in that investigation (Smith, 1978) the presence or absence of self-initiated movement was confounded with the type of action that was occurring. To illustrate, one self-initiated movement that children witnessed was chewing, an activity generally presumed to be pleasurable. There was no corresponding action that was externally caused. In contrast to the familiar act of chewing, an externally caused movement was an actor's hand being hooked and pulled up by the handle of an umbrella. Since the goal of this action is unclear and the action itself is unfamiliar, it is not surprising that children would be less likely to regard it as something the actor "wants" to do when compared to a more familiar activity such as chewing. In other words, it is important to control for

the possibility that children's desire-based explanations are influenced more by the intrinsic desirability of the action than by how the action was initiated.

Method

Subjects

Subjects were drawn from predominantly middle-class elementary schools and preschools. There were 18 children in each of two age groups: 9 female and 9 male preschoolers (range 4:7 to 5:6; mean age 5:1) and 10 male and 8 female first graders (range 6:9 to 7:6; mean age 7:1). None of the subjects from Study 1 participated in this study.

Materials

Pencil drawings were used to depict each sequence of action. The same guidelines governing depictions of action in Study 1 were used in Study 2. The actors in the drawings were humans since, along with mammals, mental states were attributed to them most often in Study 1. Refusal to explain their actions mentalistically in Study 2, when the situational features are absent, would be a more impressive demonstration of the influence the features have on mentalistic explanations than if "lower" organisms were the actors. Also, keeping the category of actors constant (human) permits a further test of the extent to which children infer types of causes solely on the basis of the biological nature of the actor. If they do so, then there should be relatively little variation in explanations across different situations in this study.

Procedure

Altogether, there were eight pairs of scenarios (see Table 6). Each scenario was illustrated by three separate drawings. The first drawing depicted the protagonists and the setting in which the action eventually occurred. The second drawing depicted the initiation of the action and the third picture depicted its occurrence. The pictures were presented to children in a top-to-bottom column proceeding from the first to last picture (Kun, 1978). After the action in the third picture was stated, children were asked to explain why the actor was doing the action and their responses were transcribed by the tester. Each picture remained on the table until the child's explanation was completed.

To introduce the experimental procedure, children were given two warm-up trials, one in which a physical answer was implied (why does laughter occur when one is being tickled?) and one in which a desire-based explanation was implied (why does one remove ice cream from the freezer?). The experimenter did not reinforce specifics of subjects' answers. Following the warm-up trials, the sequential nature of the three pictures comprising each scenario was illustrated by telling children that presenting each new picture in the story is "just like turning the pages of a book."

In 4 of the 16 scenarios the action was caused by a physical force (SI-) (see Table 6). The external causal

Table 6

Stories used in Experiment 2

STORY	SITUATIONAL FEATURE	TARGET ACTION
Pool	SI+	entering a pool headfirst
	SI-	
Sandbox	SI+	moving into a sandbox
	SI-	
Playground	SI+	going into a playground
	SI-	
Couch	SI+	reclining on a couch
	SI-	
Bracelet	PA+	throwing away a bracelet
	PA-	
Cat	PA+	carrying a cat in a laundry basket
	PA-	
Worm	PA+	smashing a worm with a wagon
	PA-	
Request	PA+	entering a kitchen upon one's request
	PA-	

Note. SI+ = scenarios in which self-initiated movement is present. SI- = scenarios in which the action is externally caused. PA+ = scenarios in which perceptual access to either the bracelet, cat, worm, or request is present. PA- = scenarios in which perceptual access to either the bracelet, cat, worm, or request is absent.

event, depicted in Picture 2, was physical contact with either a pedestrian human (couch, SI- and pool, SI-) or a human riding a bike (sandbox, SI-, playground, SI-). In four matching scenarios (SI+) the action was self-initiated in Picture 2 rather than externally caused. However, the causal agent from the SI- scenarios also appeared in Picture 2, but without contacting the protagonist. Thus, in each pairing either a causal event (e.g., "Jill pushes Allison with the bike") or a non-causal, equally visible physical event (e.g., "Mary rides by on her bike") occurred in Picture 2 and was mentioned by the narrator. If children generally assume that salient physical events are causal, then they could use the depicted physical event to explain the action for either story within a pair. In contrast to the variations in Picture 2, Pictures 1 (orienting children to the scenario) and 3 (depicting the occurrence of the action being explained) were identical in each matching pair of stories.

For the remaining four pairs of scenarios, perceptual access to a physical event shaping the action was manipulated (see Table 6). These events were a cat crawling into a laundry basket, a worm being dropped in front of a moving wagon, a bracelet being dropped into a trash bag, and a child verbally calling for another child to enter a room. Pictures 1 and 3 were once again identical within each pair, while the presence of perceptual access to the physical event was varied in Picture 2. For example, in the cat

story the second picture depicted a cat crawling under clothes in a laundry basket. For half of the subjects, the protagonist saw the cat's action (PA+) while for the other half the protagonist's back was turned away from the critical physical event (PA-). In each case, the narration accompanying the second picture noted the presence or absence of perceptual access. Children were reminded of this variable in the third picture (e.g., "She doesn't see Kitty in the basket") before the action was described.

One story from each of the eight pairs in Table 6 was administered to each subject. Of these eight stories, two were drawn from each of the four categories (SI+, SI-, PA+, and PA-) and were administered in one of six random orders. Each story was present in three of the six orders, ensuring even distribution among the subjects. The only constraints on the ordering were (a) no more than two stories in which the same critical feature was manipulated (perceptual access or self-initiated movement) were administered in a row and (b) no more than three stories were given in a row in which a critical feature was successively either present or absent.

Coding

There were two key elements coded from children's spontaneous explanations of action: (a) whether the explanation was mentalistic and (b) whether the mental explanation was directed toward the target action being explained. Regarding the first element, mental explanations

were defined as appeals to an internal drive, desire, or belief of the agent. Such explanations included appeals to beliefs (e.g., think, know), preferences/emotions (e.g., like, hate), desires/wishes (e.g., want to, gonna), traits (e.g., dumb, nice), perceptions (e.g., see, hear), and psychophysiological states (e.g., sleepy, hungry) (see Bartsch & Wellman, 1989; D'Andrade, 1987). Also, at times children used implicit expressions of desires, mentioning acquisition of the goal without explicitly specifying the actor's desire for the goal. For example, when asked why an actor was going into a sandbox, some children merely stated a goal ("to play," or "so she can build a sandcastle"). Table 7 provides various examples of the different types of mental explanations given by children.

Regarding the second element of coding, it was important to determine whether or not the explanations were "directed" toward the target action. Specifically, target actions, listed in Table 6, were the depicted actions which children were explicitly asked to explain. A mental explanation was target-directed if it (a) implied awareness of the target action and/or (b) a desire to accomplish the target action. Such explanations were considered to be plausible only in situations where the target action was either self-initiated or accompanied by perceptual access (see Table 7). In contrast, mental explanations that were not target-directed were explanations which did not suggest

Table 7

Examples of Mental Explanations Directed Toward the Target Action

Belief/Knowledge: "Because he thinks it's garbage" (bracelet, PA+)

Feelings/Emotions: "Because she hates worms" (worm, PA+)

"Because she likes to play" (playground (SI-)*

Desires/Wishes: "She wants to play outside" (playground, SI+)

"Because she sees it and she wants to play" (sandbox, SI-)*

"Because she wants to kill it" (worm, PA-)*

Desires (implicit): "So she can play" (playground, SI+)

Traits: Trait-like explanations were not used

Psychophysiological States: "Because he's getting sleepy" (couch, SI+)

"Because he's tired" (couch, SI-)*

Perceptions: "She saw him crawl under the clothes into the basket" (cat, PA+)

* = Mental explanations directed toward the target were considered as inappropriate in these instances

Note. Explanations were in response to the question of why an action, listed in Table 6, was occurring.

that the actor was motivated by a desire for the target action and/or that the actor was <u>unaware</u> that the target action was occurring. Examples of such explanations are given in Table 8.

In contrast to mentalistic explanations of action, a second general category of explanations used by some children were appeals to physical events. These occurred most often in SI- stories. Such explanations generally included mentioning the external cause of an action or describing an event that resulted in the ongoing action being explained. Examples of physical explanations are also shown in Table 8.

Sometimes, children's explanations were ambiguous in stories where perceptual access was manipulated. That is, it was unclear from the explanation if the child felt that the action was intentional. To use the cat story as an example, some explanations for why the actor was carrying the cat toward the car included, "to go on a trip," "because she's going somewhere," or "because she's going to do the laundry." From these explanations, it is not readily apparent whether or not the child believes that the actor knows that the cat is being carried in the basket. Therefore, when an explanation was applicable for situations in which perceptual access was either present or absent, the response was probed by asking the child whether the actor <u>knew</u> about the key event (e.g., "Does she know the cat is in

Table 8
Explanations Used by Preschoolers Other than Target-Directed Mental Explanations in Experiment 2

A. Other Mental Explanations

Couch (SI-) "Because he was hurt (upon being pushed)"

Cat (PA-) "Because the Kitty's in the basket and she doesn't know it"

Cat (PA+) "Because she doesn't know he's in there"*

Worm (PA-) "Because she (the actor) doesn't watch out where she's going"

Worm (PA+) "Because she didn't see it"*

Bracelet (PA+) "Because he doesn't know it's in there"*

B. Physical Explanations

Couch (SI-): "Because he pushed him on the couch and he bumped his head"

Pool (SI-): "He fell in because he pushed him"

Cat (PA-): "Because Kitty got into the basket"

* These explanations were considered as inappropriate, since they were not target-directed in the presence of self-initiated movement or perceptual access

Note. Explanations were in response to the question of why an action, listed in Table 6, was occurring.

the basket?"). Children's answer to the "know" question was taken as clarifying evidence regarding their belief about the intentionality of the act when the explanation was ambiguous. Thus, children's initially ambiguous responses were counted as target-directed mental explanations only if the subject said "yes" to the "know" question.

Finally, in rare instances two different types of answers were given by the same child. For example, one child explained that a person who was propelled toward a sandbox (SI-) was going into the sandbox "because Jill pushed her in and she fell. Then she wanted to play." In such cases, if the two answers differed in plausibility, the more plausible of the answers (given the context of the situation) was used in all analyses. Thus, in the above example the child's explanation was regarded as an appeal to a physical event.

Twenty-five percent of children's explanations were randomly chosen and coded by a second rater (blind to whether perceptual access or self-initiated movement was present). The responses were coded with regard to whether or not the explanation was a mental explanation directed toward the target. Interrater agreement was 92%.

<u>Scoring</u>

One point was given for each target-directed mental explanation. Therefore, scores could range from 0-2 for each of the four types of scenarios, PA+, PA-, SI+, SI-. Total scores could range from 0-4 when a key feature was

present (combining PA+ and SI+ stories) and also when a key feature was absent (combining SI- and PA- stories). If children correctly use target-directed mental explanations more often when self-initiated movement and perceptual access are present than when they are absent, their scores should be significantly higher for the PA+ and SI+ stories than for the PA- and SI- stories.

Results

A 2 (age) x 2 (presence or absence of a situational feature) mixed analysis of variance was conducted. Age was the between subjects variable and presence was the within subjects variable. The dependent variable was the number of mental explanations directed toward the target action. The variables of gender and order were also tested for their effect on the number of target-directed mental explanations. However, there was not a main effect of these variables, nor did they interact with any of the variables of interest (age and presence), all ps $> .09$; therefore, they will not be considered further.

The effect of age was not significant, F (1,34) = .89, n.s., meaning that target-directed mental explanations were as likely to be given by preschoolers as by first graders. It is noteworthy that a substantial number of target-directed mental explanations explicitly referred to the actor's desire, using the mental verb "want" (see Table 7 for examples). When the situational features were present (SI+ and PA+), the percentage of target-directed mental

explanations containing the mental verb "wants" was 49% for preschoolers and 36% for first graders. Preschoolers and first graders were just as likely to explicitly refer to the actor's desire this way in the SI+ stories as in the PA+ stories ($\underline{t}$s(17) = .57 and .94 respectively, $\underline{p}$s > .10). The percentages are comparable to Bartsch and Wellman (1989) who found that 30% of the time preschoolers and adults spontaneously invoked a desire term (generally "wants") to explain an action.

In contrast, target-directed mental explanations featuring expressions of belief (i.e., "think" and "know") were used infrequently by children (10% for preschoolers and 1% for first graders) in the PA+ and SI+ stories. These percentages are lower than the 18% spontaneously given by subjects in Bartsch and Wellman (1989). The difference between studies is likely due to the absence of anomalous belief stories in this study. Recall from Study 1 that anomalous belief stories require children to explain an action that is contradictory to an actor's apparent desire. A majority of belief terms in Bartsch and Wellman (1989) came in response to such stories.

A main effect of presence, $\underline{F}(1,34) = 164.57$, $\underline{p} < .001$, indicates that children used target-directed mental explanations selectively, being influenced by whether a situational feature was present. Overall, subjects were much more likely to use target-directed mental explanations in the four stories marked by the presence of a situational

feature (PA+ and SI+) (M = 3.64) than in the four contrasting stories (PA- and SI-) (M = .97). The effect of presence was significant regardless of whether self-initiated movement or perceptual access was the variable being manipulated: Target-directed mental explanations were much more common for SI+ stories (M = 1.92) than for SI- stories (M = .53), $F(1,35) = 130.99$, $p < .001$, and, similarly, for PA+ stories (M = 1.72) compared to PA- stories (M = .44), $F(1,35) = 101.04$, $p < .001$.

In the SI- stories, children often appeared to adopt what might be characterized as a Physical Stance, explaining the action in terms of the physical contact initiated in Picture 2 (see Table 8 for examples of such explanations). The percentage of times in the SI- stories that an action was explained in terms of the actor being "pushed" or propelled in some way was 61% for preschoolers and 61% for first graders. Such explanations were common even though subjects could have explained action in the SI- stories by appealing to the mental states of the actor. For example, a few children explained the action as an attempt to avoid further contact with the external causal agent (e.g., the act of moving toward a playground is occurring so that the causal agent on the bike "won't do it again").

In addition to the main effect of presence, there was a significant interaction between age and presence, $F(1,34) = 7.14$, $p < .025$. The interaction reveals that preschoolers were significantly more likely to use target-directed mental

explanations when the features were absent (PA- and SI- stories) (M = 1.33) than first graders (M = .61), $F(1,34)$ = 4.17, $p < .05$. In contrast, first graders were significantly more likely to use them (M = 3.83) than preschoolers (M = 3.44) when the key feature was present (PA+ and SI+), $F(1,34)$ = 5.17, $p < .05$.

Examining the interaction of age and presence more closely shows that the age differences in the frequency of target-directed mental explanations primarily occurred in the PA stories. An age by presence interaction was not significant in the SI stories, $F(1,34)$ = 1.94, $p > .10$ but was significant in the PA stories, $F(1,34)$ = 9.36, $p < .01$. The age difference in the number of target-directed mental explanations in the PA- stories (M = .67 for preschoolers and M = .22 for first graders) was significant, $F(1,34)$ = 5.44, $p < .05$ (see Table 9). The reverse occurred when the crucial feature was present (PA+) as first graders were more likely to use target-directed mental explanations (M = 1.89) than preschoolers (M = 1.56), $F(1,34)$ = 4.14, $p = .05$ (see Table 9). These results suggest that even though children at both ages correctly discriminated between PA+ and PA- stories, first graders did so more often than preschoolers. They were more likely to use target-directed mental explanations when perceptual access was present and less likely to use them when perceptual access was absent. Unlike the differences in performance in the PA stories, children were equally successful in the SI stories. That is,

Table 9
Mean Number of Target-Directed Mental Explanations in Experiment 2

	SI+	SI-	PA+	PA-
Pre-K	1.89	.67	1.56	.67
1st	1.94	.39	1.89	.22
Mean	1.92	.53	1.72	.44

Note. For both age groups, the differences between the SI+ and SI- stories, and the differences between the PA+ and PA- stories, are significant, $p < .01$. Scores ranged from 0-2.

children at both ages were equally likely to use target-directed mental explanations in the SI+ stories and equally likely to use other explanations in the SI- stories.

Preschoolers' difficulties in the PA stories, relative to first graders, are further illustrated by examining the varying number of times they explicitly referred to the actor's lack of perceptual access in the PA- stories. In these stories, 44% of first graders' explanations explicitly mentioned the actor's lack of perceptual access (e.g., "Because he doesn't see it [the bracelet] and he's taking the garbage out"; "Because she didn't see him [the cat]"). In contrast, preschoolers explicitly noted the lack of access only 22% of the time.

Overall, 36% of preschoolers' explanations in the PA stories were probed and 42% of first graders' explanations were probed. Accurate judgments of the actors' knowledge, on the basis of perceptual access, occurred 69% of the time for preschoolers and 93% of the time for first graders. For preschoolers 44% of the probes were in the PA+ stories, as were 41% of the probes for first graders. The remainder (56% and 59% respectively) were in the PA- stories.

A final level of comparison involves assessing differences in explanations between each pair of stories (eight pairs altogether) (see Table 6). First graders discriminated between the stories in nearly every pair (the exception being the playground story), offering more target-directed mental explanations when the situational feature

was present than for the matching story in which the feature was absent, all $ps < .01$ (Bonferroni-corrected Fisher test). For preschoolers, significant differences in explanations emerged in three stories (the Pool, Couch, and Bracelet stories), $p < .01$ (Bonferroni-corrected Fisher test).

Discussion

The primary goal of Study 2 was to investigate the circumstances influencing when and how children mentalistically explain action. To this end, children's spontaneous explanations of action were examined to see if they differed as a function of the presence or absence of (a) perceptual access to a key event and (b) self-initiated movement. Results clearly demonstrated a sensitivity among preschoolers and first graders to these situational features, since target-directed mental explanations were given significantly more often in their presence than in their absence. A number of points follow from, and amplify, this finding.

First, Study 2 extends Bartsch and Wellman's (1989) examination of children's spontaneous explanations of action in two ways. It replicates, under a set of stories and circumstances different from Bartsch and Wellman (1989), the assertion that young children's explanations of action often spontaneously refer to the mental states of the actor. This extension is important because, to a large degree, studies of children's theory of mind have been limited to procedures in which children predict (rather than explain) action on

the basis of another's belief or desire. Few studies address young children's spontaneous explanations of action even though the richness and importance of a theory of mind often comes from its usefulness as a tool to construe and explain particular actions performed by oneself or another. Although other rudimentary systems of explanation exist for children, such as the Physical and Design Stances, the results of this study illustrate that the explanatory system of choice, spontaneously invoked to explain action in the SI+ and PA+ stories, was mentalistic in nature.

In a complementary sense, Study 2 also illustrates that young children predictably refrain from imputing target-directed mental explanations under specific sets of circumstances (i.e., when either perceptual access to a key event or self-initiated movement is lacking). Such evidence makes clear that the theory of mind of preschoolers and first graders is not overextended and uniformly applied to all action. Instead, young children were sensitive to which actions were explicable via specific concepts within their theory of mind and which actions were inexplicable given the purview of their theory of mind. They did so by accounting for how the action was occurring and inferring its cause on that basis. Consistent with Study 1, such considerations were more important than who was doing the action, as explanations varied even though the biological category of the actors remained constant.

Preschoolers properly adjusted their explanations of action just as often as first graders when the feature of self-initiated movement was manipulated, but did so less often when perceptual access was varied. It is possible that preschoolers were simply less sensitive than first graders to whether perceptual access was present and, therefore, less accurate in their judgments of knowledge. For example, in this study preschoolers accurately attributed knowledge, when probed, 69% of the time compared to 93% for first graders. If they were not fully attuned to the perceptual activity of the actor, its occurrence or absence may have been overlooked and quickly forgotten, resulting in target-directed mental explanations when the actor was unaware of the target (and vice versa).

More generally, the present methodology had a greater likelihood of producing false negatives in children's performance rather than false positives. For example, reliance on open-ended explanations instead of providing a forced-choice may have resulted in underestimating the abilities of some children. In addition, the key features, perceptual access and self-initiated movement, were embedded within a story-like context and perhaps were not as salient as they might have been otherwise. It is easy to imagine ways to make them more salient; for example, by telling subjects to pay particular attention to perceptual access or self-initiated movement and then reminding them of their presence or absence before asking for an explanation. Doing

so, however, increases the risk of overestimating the importance children spontaneously attribute to the situational features when inferring the cause of an action.

Future research could employ these methodological changes and address the nascent abilities of even younger children to parse the world according to the situational features examined in Study 2. Methodological changes, such as employing a forced-choice between explanations, would serve to assess whether 3-year-olds, and perhaps even 2-year-olds, construe the causes of action differently depending upon whether or not self-initiated movement or perceptual access is present. Given the results of Study 2, in which preschoolers tended to do better in the SI stories than in the PA stories, it might be expected that sensitivity to self-initiated movement would emerge prior to any sensitivity to the presence of perceptual access. Evidence of the early ability to map mental concepts onto the distinction between self-initiated and externally caused movement would support the contention of Premack (1990) that the foundational concept of agency emerges in infancy. He argues that infants' ability to perceptually distinguish between self-initiated and externally caused movement is the basis upon which they interpret the intentionality of an action. If these rudimentary interpretive capabilities emerge during infancy, then when children's first verbalizations of words like "wants" and "gonna" occur (around age 2 and 3) (e.g., Hood & Bloom, 1979), they should

use these terms only when explaining self-initiated movement.

GENERAL DISCUSSION

The focus of this research was to explore a basic question regarding children's thinking about the mind: When do children impute mental states to others? This is an important question because it speaks to the issues of how theory-like children's conception of the mind is and, also, the mechanisms by which such a theory might develop. In the following discussion, these topics are discussed in turn.

If, as often argued, children have some form of a theory of mind (e.g., Gopnik, 1993), it is reasonable to suspect that principles exist which signify if (and how) an action is explicable by that theory. Theories must specify the situations in which their constructs can and cannot meaningfully explain an occurrence. For example, psychologists do not apply their cognitive theories to astronomical phenomena because broad principles (e.g., cognitive theories are directed toward explaining human behavior) delineate the spheres of inquiry for which the theories are relevant. In the same way, a theory of mind must meaningfully delineate when and how phenomena are explicable by its explanatory constructs (e.g., belief and desire).

Consider, for example, a situation in which two movers are carrying a table from one room to the next. What is it

about that action which would normally compel one to explain it in terms of the beliefs and desires of the movers rather than (or in addition to) the beliefs and desires of the table, the biological makeup up the movers, the time of day, wind velocity, etc.? If children's thinking about the mind is theory-like, one would suspect that situational features exist which consistently enable them to extract from such novel, perceptually complex situations the information needed to correctly infer that the action is occurring because of the beliefs and desires of the movers.

To answer whether this is the case for young children, Studies 1 and 2 examined whether self-initiated movement, when variable, and perceptual access to a key event were characteristics of actions that made them particularly conducive to target-directed mentalistic explanations. Altogether, children witnessed a number of actions in which (a) the actions were committed by a wide range of actors, (b) plausible design explanations were pitted as alternatives to mental explanations, and/or (c) the presence of the features was varied. Given these manipulations, four possible patterns of explanation could have emerged: Mentalistic explanations could have (a) never occurred, (b) always occurred, (c) occurred randomly, or (d) occurred systematically. The results of Study 1 and Study 2 clearly illustrate that the last pattern is actually the one that characterizes the explanations of young children and adults. Target-directed mental explanations were common in the

presence of the features (even when a plausible alternative was present) and were also generalized, by children, across different actor categories. In comparison, the removal of self-initiated movement or perceptual access resulted in a marked decrease in target-directed mental explanations.

These results suggest that children abstract features of action when construing its cause and that doing so plays a vital role in learning to generalize mentalistic explanations to new situations. Indeed, without the ability to rely on situational features in inferring the cause of an action, children would have to learn, on a case by case basis, why an action was occurring. Since mental states are unobservable, such learning would likely require an overt confession on the part of the actor signifying her beliefs or desires. However, young children capably generalize across situations, identifying defining features that immediately categorize an occurrence as potentially explicable or inexplicable by their theory of mind.

Not only do children accurately generalize across situations (Study 2), but they also tend to inaccurately generalize across biological categories of actors (Study 1). This overgeneralization is consistent with Premack (1990), who has suggested that self-initiated movement is not a domain-specific cue of intentionality for infants. He argues that the self-initiated motion of various objects, varying from boxes to humans, is regarded by them as intentional. In this study, children's overattribution of

beliefs and desires to artifacts and insects, compared with adults, may be the result of a rigid adherence to the importance of the situational features surrounding an action. In fact, one feature of theories is that they can lead to the misintepretation of information when a person is "biased" by their precepts (Astington & Gopnik, 1991). It may be that children's theory of mind biases them to note particular features of action that, when present, override perceptual/biological features of the actors. Thus, although in their appearance and biological make-up humans, ants, and computers have little in common, when their actions were construed within the theoretical framework, a specific commonality between them may have surfaced because features of their actions satisfied children's theoretically important preconditions. As a result, even though young children are not always animistic (as noted in the Introduction), they nevertheless tended to impute mentalistic explanations to artifacts.

Although children imputed target-directed mental explanations systematically across Studies 1 and 2, one might argue that consistency alone does not mean that children's thinking about the mind is "theory-like." In fact, consistency may simply be the result of learning over time to associate specific mental states with specific types of action. For example, children may learn from their own experiences that action which is variable, self-initiated, and accompanied by perceptual access is often driven by

their beliefs and desires directed toward the action. They may extrapolate mentalistic causes of action to others on the basis of this association. Therefore, consistency in their explanations may simply be a byproduct of consistencies among their own phenomenological experiences.

Even so, it is important to dissociate the mechanisms by which consistency emerges from the "theory-like" function the situational features perform. To return to the example of the "moving table," one might argue that children explain the action by simulating their own experiential history of carrying objects and extrapolating such experiences to the movers (e.g., Harris, 1991). Even if this is true, at a more basic level one must ask how children know that this action is one that can be explained by simulation whereas another action, perhaps the movement of leaves by the wind, requires no simulation. Clearly, features such as self-initiated movement and perceptual access narrow the field of occurrences that can be explained by simulation, thereby acting as theoretical principles in carving the world into phenomena explicable and inexplicable via mental concepts.

Nevertheless, if these situational features act as theoretical principles delineating phenomena into those which are and are not explicable via beliefs and desires, the question of how they come to play the role they do is still open. Answering this question addresses the nature of the mechanisms by which a theory of mind develops. As noted earler, it may be that through experience, children learn

that most times when their action is self-initiated, variable, and accompanied by perceptual access, then it is volitional. They may assume that the same experiences are true for others under those same circumstances, including the actions of insects and artifacts (children's inferences about the phenomenological experiences of species other than humans are interesting and, for the most part, also an open questions). Another possible mechanism, however, is that sensitivity to these situational features is hardwired, and perhaps innate (see Premack, 1990), suggesting that sensitivity to how an action occurs may be the basis for the later emerging concepts of belief and desire. For example, children may first come to divide the world into objects which are either self-propelled or externally caused. Concepts of volition and desire may then emerge as ways to interpret this distinction. That is, opposite the simulation view, the mental concepts may come <u>after</u> sensitivity to the situational features. The question then is whether (a) the concepts are derived strictly from phenomenological experience and then, over time, gradually become associated with variable self-initiated movement and perceptual access or (b) distinguishing the situational features comes first and gradually, children come to learn that these distinctions among different actions can be explained by the beliefs and desires of the actors. This realization may emerge from learning that target-directed

mental states only covary with action characterized by the situational features.

To disentangle the interrelation between conceptualizing the mind and parsing the world according to the situational features investigated in this study, one must address how very young children distinguish and explain action. Future research should examine the various features of action that are salient to toddlers and used by them to discriminate among occurrences. The consistency of the discriminations across situations, the timing of the emergence of sensitivity to different features, and the salience of the various situational features are all issues worthy of investigating. Following such investigations, it would then be possible to assess whether distinctions among actions are made independently of children's target-directed mental explanations and whether such explanations emerge prior to the perceptual distinctions of interest.

REFERENCES

Astington, J.W., & Gopnik, A. (1991). Theoretical explanations of children's understanding of the mind. British Journal of Developmental Psychology, 9, 7-32.

Bartsch, K., & Wellman, H. (1989). Young children's attribution of action to beliefs and desires. Child Development, 60, 946-964.

Berzonsky, M.D., Miller, P.H., Woody-Ramsey, J., Harris, Y. (1988). The relationship between children's judgments of animacy and sentiency: Another look. Journal of Genetic Psychology, 149(2), 223-238.

Bullock, M., & Gelman, R. (1979). Preschool children's assumptions about cause and effect: Temporal ordering. Child Development, 50, 89-96.

Carey, S. (1985). Conceptual change in childhood. Cambridge, MA: MIT Press.

D'Andrade, R. (1987). A folk model of the mind. In D. Holland & N. Quinn (Eds.), Cultural models in language and thought (pp.112-150). New York: Cambridge University Press.

Dennett, D.C. (1987). The intentional stance. Cambridge, MA: MIT Press.

Dretske, F.I. (1988). Explaining behavior: reasons in a world of causes. Cambridge, MA: MIT Press.

Flavell, J.H., Miller, P.H., & Miller, S.A. (1993) Cognitive development (3rd ed.), Englewood Cliffs, NJ.: Prentice-Hall.

Fodor, J. (1987). Psychosemantics: The problem of meaning in the philosophy of the mind. Cambridge, MA: MIT Press.

Gelman, R. (1990). First principles organize attention to and learning about relevant data: Number and the animate-inanimate distinction. Cognitive Science, 14, 79-106.

Gelman, R., Spelke, E.S., & Meck, E. (1983). What preschoolers know about animate and inanimate objects. In D. Rogers & J.A. Sloboda (Eds.), The acquisition of symbolic skills (pp.297-326). New York: Plenum Press.

Gelman, S.A., & Kremer, K.E. (1991). Understanding natural cause: Children's explanations of how objects

and their properties originate. Child Development, 62, 396-414.

Gelman, S.A., & Wellman, H.M. (1991). Insides and essences: Early understandings of the non-obvious. Cognition, 38, 213-244.

Gopnik, A. (1993). How we know our minds: The illusion of first-person knowledge of intentionality. Behavioral and Brain Sciences, 16, 1-14.

Gottfried, G.M., & Gelman, S.A. (1992, April). Domain differences in children's understanding of internal cause. Presented at the Conference on Human Development, Atlanta, GA.

Harris, P.L. (1991). The work of the imagination. In In A. Whiten (Ed.), Natural theories of mind (pp. 283-304). Oxford: Basil Blackwell.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. American Journal of Psychology, 57, 243-259.

Hood, L., & Bloom, L. (1979). What, when, and how about why: A longitudinal study of early expressions of causality. Monographs of the Society for Research in Child Development, 44 (6, Serial No. 181).

Inagaki, K., & Sugiyama, K. (1988). Attributing human characteristics: Developmental changes in over- and underattribution. Cognitive Development, 3, 55-70.

Johnson, C.N. & Wellman, H.M. (1982). Children's developing conceptions of the mind and brain. Child Development, 53, 222-234.

Keil, F.C. (1989). Concepts, kinds, and cognitive development. Cambridge, MA: MIT Press.

Keil, F.C. (1992). The origins of an autonomous biology. In M.R. Gunnar & M. Maratsos (Eds.), Minnesota symposia on child psychology: Vol.25. Modularity and constraints in language and cognition (pp. 103-138). Hillsdale, NJ: Erlbaum.

Kun, A. (1978). Evidence for preschooler's understanding of causal direction in extended causal sequences. Child Development, 49, 218-222.

Leslie, A.M. (1984). Spatiotemporal continuity and the perception of causality in infants. Perception, 13, 287-305.

Lillard, A.S., & Flavell, J.H. (1990). Young children's preference for mental state versus behavioral descriptions of human action. Child Development, 61, 731-741.

Mandler, J.M. (in press). How to build a baby: II. Conceptual primitives. Psychological Review.

Michotte, A. (1963). The perception of causality. London: Metheun.

Premack, D. (1990). The infant's theory of self-propelled objects. Cognition, 36, 1-16.

Smith, M.C. (1978). Cognizing the behavior stream: the recognition of intentional action. Child Development, 49, 736-743.

Springer, K., & Keil, F.C. (1991). Early differentiation of causal mechanisms appropriate to biological and nonbiological kinds. Child Development, 62, 767-781.

Wellman, H.M. (1990). The child's theory of mind. Cambridge, MA: MIT Press.

Wellman, H.M., & Gelman, S.A. (1992). Cognitive development: Foundational theories of core domains. In M.R. Rosenzweig & L.W. Porter (Eds.), Annual Review of Psychology (Vol. 43) (pp. 337-375). Palo Alto, CA: Annual Reviews Inc.

BIOGRAPHICAL SKETCH

Derek Montgomery was born July 2, 1965, in Toronto, Ohio. He graduated summa cum laude with a B.A. in psychology from Ohio State University in 1987. In 1991 he received his M.S. in developmental psychology from the University of Florida. His research interests center around children's metacognitive development and their understanding of invisible mechanisms of causation.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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